POTATO PACKINGHOUSES—GUIDELINES For PLANT LAYOUT

Marketing Research Report No. 975

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UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE

This report is one of several on the results of research conducted to minimize marketing costs for potatoes by developing improved methods, equipment, operating procedures, and facilities for preparing potatoes for market.

This study was conducted under the general supervision of Joseph F. Herrick, Jr., investigations leader, and Lewis A. Schaper, agricultural engineer, Agricultural Research Service.

The work was performed at the Red River Valley Potato Research Center, East Grand Forks, Minn., and in selected packinghouses in the Red River Valley of North Dakota and Minnesota.

The author thanks those packinghouse operators who made their facilities available for this study. The assistance of equipment suppliers who provided information on the various items of equipment is also gratefully acknowledged.

Related reports of general interest to the potato industry are as follows:

Bin Fronts for Potato Storages. U.S. Dept. Agr. Mktg. Res. Rpt. 893. July 1971.

Handling Potatoes From Storage to Packing Line—Methods and Costs. U.S. Dept. Agr. Mktg. Res. Rpt. 890. March 1971.

Lateral Pressures on Walls of Potato Storage Bins. U.S. Dept. Agr. ARS 52–32. June 1968.

Powered Bulk Scooping in Potato Storages. U.S. Dept. Agr. Mktg. Res. Rpt. 916. March 1971.

Shell Ventilation Systems for Potato Storages in the Fall Crop Area. U.S. Dept. Agr. Mktg. Res. Rpt. 579. January 1963.

Storage of Fall-Harvested Potatoes in the Northeastern Late Summer Crop Area. U.S. Dept. Agr. Mktg. Res. Rpt. 370. February 1960.

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POTATO PACKINGHOUSES—GUIDELINES FOR PLANT LAYOUT

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SUMMARY

Commercial potato-packing facilities in the Red River Valley were studied to determine the factors to be considered when planning potato packing-line layouts. A systematic procedure for developing a plant layout is presented.

Layouts for three synthesized potato-packing operations were developed to illustrate the operating procedures, work methods, and equipment common to the potato-packing industry. These layouts emphasize mechanization of material handling within the plant and proper planning for expansion of the enterprise. Each layout was designed to provide certain packing rates and container options.

The operations in preparing potatoes for market are discussed in general. The equipment required to perform these operations also is noted in general. The specific equipment required for the example layouts is described in detail and estimates of its initial cost are given. Crew requirements for operation of the example packing lines are also estimated.

By following the layout planning procedure shown, adopting the features illustrated, and utilizing the equipment information provided, packinghouse operators should be able to develop effective, efficient, and economical layouts.

INTRODUCTION

Potatoes that reach the consumer in their whole raw form are prepared for market through a series of processes, usually including cleaning, sorting, sizing, and packaging. This preparation is accomplished in potato packinghouses located in the production areas and in the heavily populated consuming centers of the country. These packinghouses range in size from very small plants with only limited packing capabilities to very large plants capable of packing large quantities of potatoes in many types of containers. A large modern packinghouse requires a substantial investment in handling and packing equipment and plant facilities.

The potato-packing firm attempts to meet the demands of the marketplace with the potato crop it has available each year. To do this effectively enough to insure a profit for the firm requires the proper use of all personnel, equipment, and facilities available in the plant. In addition, the plant layout should provide for the quickest flow of material through the plant with the least amount of handling and at the lowest cost. Outdated facilities are costly in terms of money, time, labor, and opportunity loss. A change in the layout of an outdated packing line or the development of an entirely new packing facility should be planned carefully and systematically. This publication was prepared to assist in such planning.

This study was undertaken to develop guidelines for planning potato packinghouse layouts that allow more efficient and flexible operation- tors to be considered in layout planning ar and three example layouts have been p Methods, equipment, and facilities used and small commercial potato packinghous Red River Valley area were studied du development of these layouts. Processes an ment known to be used in packing plants areas of the United States are also include of the operations and facilities may be co typical of the industry at this time. Howe example layouts emphasize more mechaniz material handling in the plant than is co practiced by the industry.

PLANT LAYOUT

The layout of a potato packinghouse must coordinate physically the five basic factors found in any industrial management situation—capital, labor, equipment, materials, and markets.

The goal of arranging equipment properly to provide for the quickest flow of the product at the lowest cost and with the least amount of handling must be met from the time the potatoes enter the packinghouse until the packaged product is shipped out.

A major part of the work in a potato packinghouse is handling. A good layout will provide for careful, efficient handling during all the operations, including cleaning, sorting, packaging, and shipping.

Ideally, the layout is developed first and the building is altered to fit the layout, or for a new structure it is constructed around the layout. Often an existing structure cannot be altered and a new layout must be accomplished within the confines of the building.

The need for a change in the layout of an existing facility is usually indicated by unfavorable costs. An improper layout can also be indicated by bottlenecks, congestion, complaints, damage, manual handling, re-handling, poor quality, accidents, and delays. Then, too, a change in the layout of existing equipment is indicated periodically as new methods and equipment become available or as marketing changes occur.

Whether the need be for a change in a layout or for a new layout, it is best to use a systematic approach. The following discussion describes the factors to be analyzed and the procedure to be followed in planning layouts for potato packinghouses.

Product Analysis

The initial step in the layout procedure is to determine the production capacity required of the packinghouse. Both annual and hourly volumes and both present and future needs should be considered. When these volumes are known or can be closely estimated, the layout can be designed to provide for both anticipated overall expansion and anticipated changes in the output of any of the various categories of the product.

The present annual volume of production required in the packinghouse is based on (1) the number of acres of potatoes grown for direct packaging or for storage and later packaging, (2) the yield per acre, (3) the amount of storage available at the plant, (4) the amount of potatoes shipped into the plant from other areas for packaging, and (5) any seasonal limitations on markets, raw product, labor, storage, or transportation. The future annual voume may be estimated by considering any possible changes in the preceding five factors.

Hourly production rates are based on (1) annual volume, (2) number of hours the packinghouse can operate annually, (3) shipping schedules, (4) availability of labor, (5) availability of transportation, (6) market demand, and (7) potato quality.

The product analysis should also include the different types of containers to be used and their related packing costs. One should determine the amount of the potato crop that can be packed in several types of container and the amount suitable for only one type of container. This product analysis will aid in selecting the proper type, size, and amount of equipment required for the plant and will further aid in its correct location in the layout.

Operation Analysis

Several distinct operations are required when preparing potatoes for market in packinghouses. Such operations as receiving, prograding, washing, grading, and sizing must be sequenced properly. However, the need for material-handling equipment and temporary storage space in the packinghouse must not be overlooked. Cull and undersize tubers must be collected from various points for disposal. Packing-material requirements and the point at which the materials should enter the packing process should be analyzed. A process-flow chart, as in figure 1, can be very useful for visualizing the entire sequence of operations and their interrelationships. It shows the sequence of operations, inspections, transfers, and storages required in a typical potato-packing process.

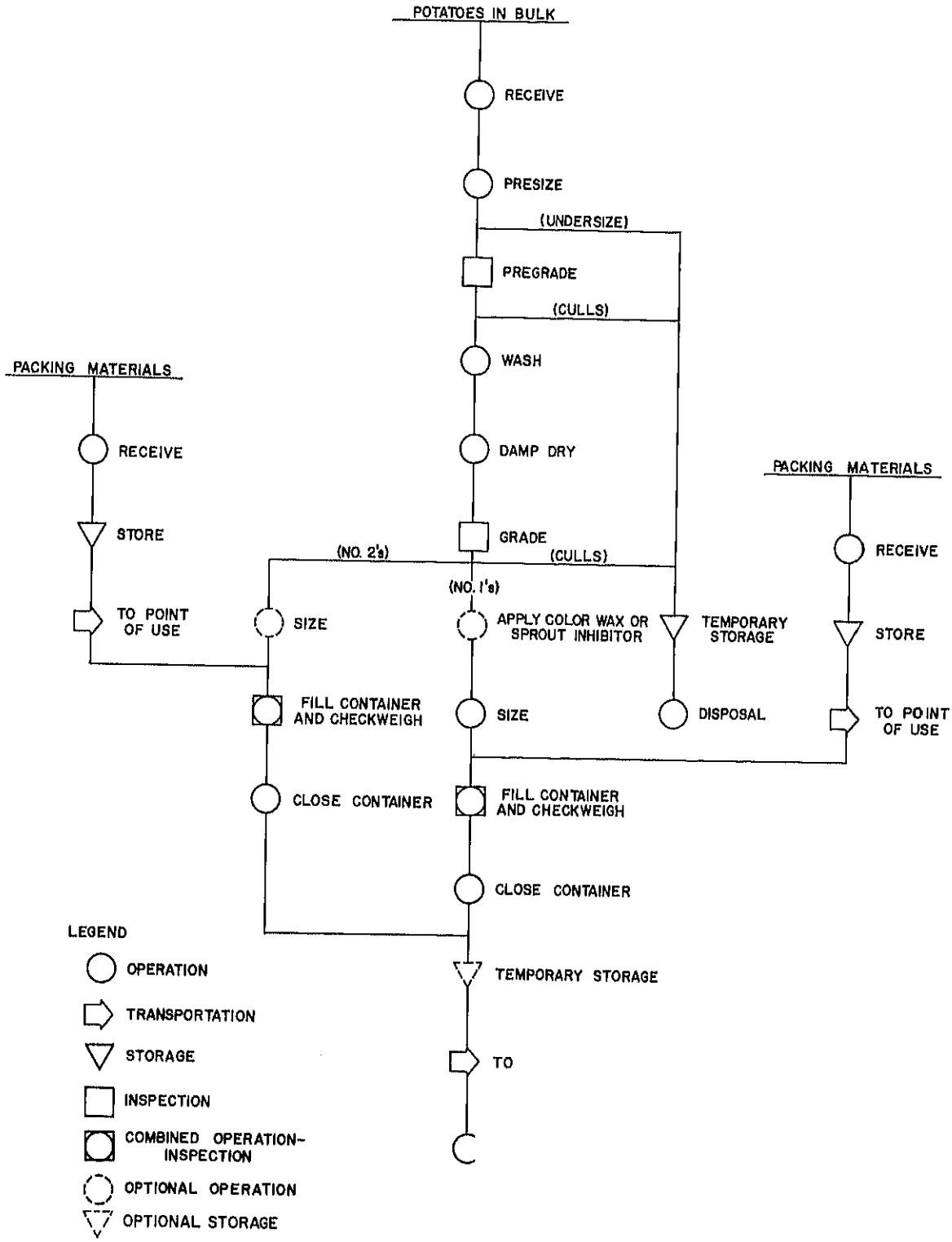

FIGURE 1.—Sequence of operations in a ty

Equipment Selection

Once the sequence of operations has been established, equipment selection can go forward, based on the hourly production rate determined from the product analysis. The capacity of each item of equipment must be determined independently for its specific location in the layout. The receiving equipment must be capable of handling the entire flow of incoming potatoes, but other items need handle only parts of this total, because some of the potatoes are removed along the way.

Some equipment must be wider to perform its function at the rated line capacity. However, a standard continuous width is useful for smooth product transfer and easier equipment installation. Therefore, certain items of equipment will have an excess capacity and others will just meet the rated line capacity. This built-in excess capacity can be utilized effectively in plant layout as a means of increasing the line capacity without resorting to a complete change in layout when expansion is desired.

The selection of equipment should be based on an economic analysis of the alternative types available. Factors to be considered are (1) annual costs, (2) labor requirements, (3) space and utility requirements, (4) effect on quality, (5) maintenance requirements, and (6) flexibility of operation. These factors could not be given more than a cursory evaluation in developing the layouts for this report, but such data should be carefully developed for an actual plant layout. Some of the equipment used for the example layouts in this report was selected for illustration purposes only; for example, the receiving equipment in each example layout is different so as to show the three types available, although any one type could conceivably have been used for all three layouts.

Analysis of Supporting Services

Supporting service areas such as temporary storage space, shipping facilities, offices, and employee facilities should be carefully planned. The adequacy of their type, size, and location directly affects the overall plant efficiency.

Space for temporarily storing either the bulk potatoes or the filled containers for several categories of grade and type of container is necessary in the larger plants. Usually the flow to such a category is relatively low, and the product must be accumulated until a full shipment is available. Space to handle, store, and segregate these lots should be provided.

When designing a potato packinghouse, the shipping facilities must receive special consideration. Factors such as mechanization, space, carrier codes, climate, and variety of vehicles require attention, with emphasis on the number and size of transporting vehicles to be accommodated—both at present and in the future.

Facilities at the packinghouse may include space for a plant office and general and private offices. The plant office should be located so that plant activities can be observed readily at all times. Activities in the general and private offices require both an isolation from and an access to the packing line.

Employee facilities should include adequate restrooms, cleanup facilities, and a "break room."

Developing the Layout

The packing line layout is planned with the aid of the process-flow chart and scaled equipment templates. The templates are very useful in visualizing alternative equipment and allow easy exploration of various ideas for layout improvement. Rearrangement of the templates on the layout board continues until the layout that provides optimum flow of product and materials in the packing line is determined. The supporting service areas are then positioned around the packing line to complete the layout. Finally, the resulting layout is drawn.

Planning the Building

The building can be designed to provide efficient receiving and shipping facilities. Its walls and columns can serve as supports for efficient material-handling equipment. It can be fitted with mezzanines, balconies, and bulk bins to fully utilize its overhead space. It can provide the necessary lighting, heat, office space, and employee facilities that help to promote high productivity.

Building dimensions and design characteristics should include plans for expansion of the enterprise, either within the existing structure or by additional construction.

Selecting the Plant Site

Some packinghouses may require only a small parcel of land near a railroad siding; others may be sprawling storage-packinghouse combinations requiring several acres of land for the buildings, railroad siding, driveways, and service facilities.

One should try to visualize the appearance of the fully developed enterprise including future expansion. Then selecting a site and locating buildings on the site can be done on the basis of these long-range plans. A building improperly located on a site becomes a permanent restriction.

Factors to be considered in site selection are (1) location with respect to potato-growing areas and to highways and railroads, (2) availability of labor, (3) availability of utilities, (4) site size and space for expansion, (5) local regulations and tax rates, (6) special climate conditions, (7) topography and soil characteristics, and (8) preparation requirements of the site.

PACKINGHOUSE OPERATIONS

All potato packinghouses, whether large or small, perform similar operations in preparing the potatoes for market. The larger plants simply do more within a given operation, such as packing many types of consumer packages rather than only one or two. The size, type, and amount of equipment required to do this may vary greatly between plants, but the operation is still that of filling a container. The general categories of packing operations are shown in figure 1 and are itemized for further explanation here.

Preparing the Product

Receiving

Potatoes are usually brought to the packing line by fluming. The receiving operation at the packing line then consists of continuously removing the potatoes from the water as they arrive at the sump and delivering them to the initial piece of equipment at the packing line. The operation is usually accomplished by (1) transferring with a draper-chain conveyor, (2) lifting vertically with a bucket-type elevator, or (3) lifting with flowing water through a pump and pipe.

The draper-chain conveyor (fig. 2, *A*) separates the potatoes from the fluming water at the sump, conveys them up an incline, and deposits them on the packing line. The angle of incline for the conveyor is limited to about 35° when standard draper-chain rods are used and to about 45° when flighted chain is used. At slopes greater than these, the tubers tend to roll back down the incline. Speed and agitation of the chain should be minimized for this operation. The necessary rate of flow may be obtained by increasing the width of the unit.

The vertical elevator (fig. 2, *B*) requires only minimal floor space. A short section of draper chain is one of the most effective feed mechanisms for the elevator. The tubers are carried upward in open-bottom troughs or buckets and deposited on the packing line. Here, too, speed should not be excessive. Proper flow rate is obtained by using the correct width and spacing of the troughs. A device to dislodge loosely carried tubers from the filled troughs while they are still near the water level will prevent them falling from a greater height.

Equipment used with the pumping method of receiving also requires minimal floor space outside of the sump area. The potatoes enter a special pump (fig. 2, *C*) in the sump, are forced upward with flowing water through a large pipe, and are deposited on the packing line, where water and tubers separate. Water from the system may be used effectively in the main fluming operation and for cull removal.

Presizing

After leaving the receiving equipment, the potatoes are moved across either a single-screen sizer (fig. 3, *A*) or a constant-pitch roller sizer (fig. 3, *B*). Tubers smaller than the required minimum pass through the openings in the sizer and are removed from the packing line. Some dirt and trash are also removed. The tubers that do not pass through the screen or rollers continue across the sizer and enter either a pregrading or a washing operation.

Pregrading

Pregrading is optional in some packinghouses. It is the removal of obvious cull potatoes prior to washing. Workers remove the culls as the potatoes

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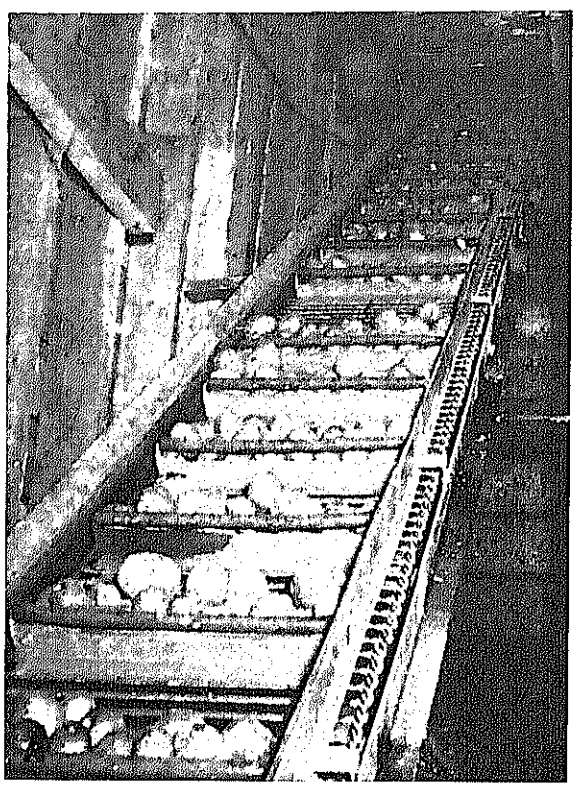
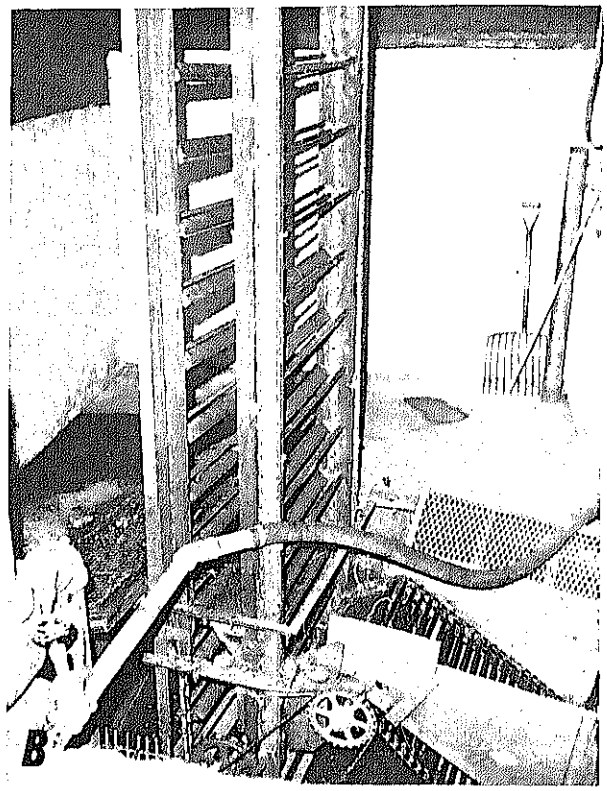




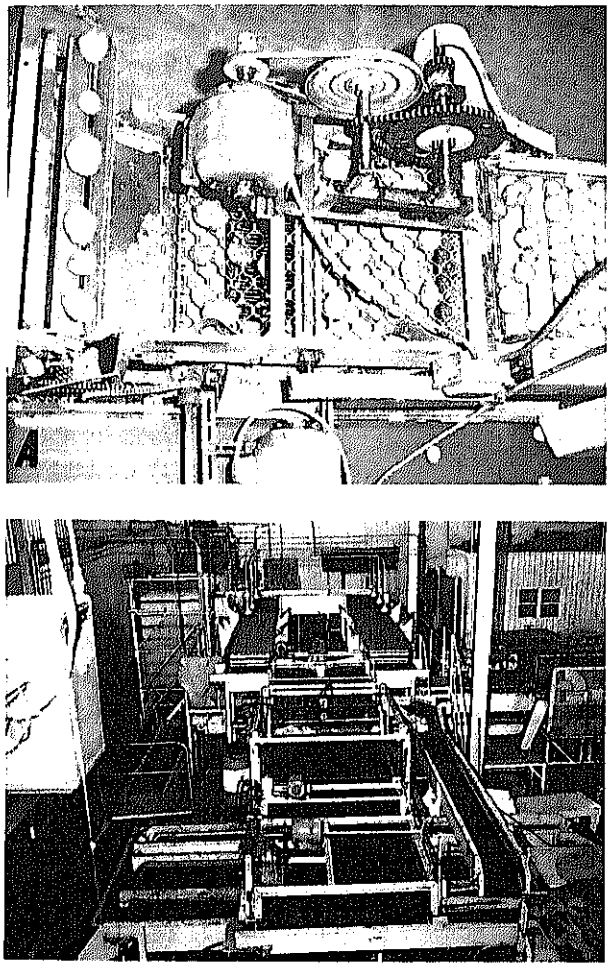
PN-3189, PN-3190, PN-3191

FIGURE 2.—Receiving equipment common to potato packinghouses: *A*, Draper-chain conveyor; *B*, bucket-type vertical elevator; and *C*, potato pump.

pass before them on a roller table (fig. 4). Whether to use pregrading depends largely on the quality of the incoming product. Removal of culls at this point can reduce the load in the washer and at the main grading table. Higher rates of flow and narrower grading tables are allowable for the pregrading operations, since only obvious culls are removed.

Washing

Potatoes move from the pregrader into the washer (fig. 5). A series of rotating brush rollers and water sprayed under pressure combine to remove dirt from the tubers as they pass through the machine. Washers with transverse brush rollers are more commonly used than those with longitudinal ones. This arrangement facilitates the use of different types of brush rollers within the same machine. By varying the spray nozzle types, specific washing and rinsing action can be provided from point to point in the washer. The washer should be at least 10 brush rollers in length.[1] Washers of a given width generally do not have the capacity found in other items of equipment in the line. If all equipment is to be utilized to its fullest, the washer, sponge-dryer combination should be wider than the rest of the line.



PN–3102, PN–3103

FIGURE 3.—Presizing with a single-screen sizer (*A*) or a constant-pitch roller sizer (*B*).

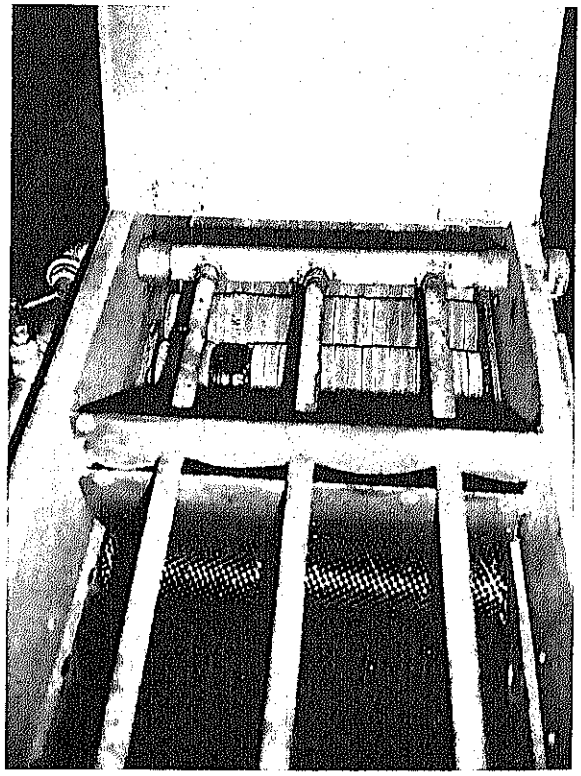
PN–3104

FIGURE 4.—Pregrading station where worker is removing obvious culls prior to washing.

Water Removal

The potatoes are moved from the washer onto a series of rollers covered with sponge rubber (fig. 5). This set of rollers generally is built in combi-

[1] MAINE COOPERATIVE EXTENSION SERVICE. THE SELECTION OF POTATO GRADING AND HANDLING EQUIPMENT. Maine Agr. Ext. Serv. Leaflet 7, 8 pp., illus. [n.d.]



PN-3196

FIGURE 5.—A washer, sponge-dryer combination.

nation with the washer. The sponge-rubber rollers absorb moisture from the tubers, and a set of wringer rollers squeezes this water from the sponge rubber. A minimum of eight rollers is required.[2]

Heated-air dryers may be used in some plants to remove more of the moisture from the surface of the potatoes before they are packed. The location of these units in the layout generally is such that drying will follow the grading operations. This location minimizes the amount of potatoes to be dried. The potatoes are carried through the heated-air flow within the dryer by metal roller conveyors that also rotate the potatoes. Single-, double-, and triple-pass units are available in various lengths and widths to match the drying requirements of the plant.

Grading

The potatoes are moved from the combination washer, sponge-dryer to the grading table. Workers stationed at the table remove cull potatoes and U.S. No. 2 grade potatoes to separate chutes or belts. The roller-type grading table rotates the tubers so that all sides may be viewed as they pass in front of each grader. The conveying speeds used for grading tables range from 20 to 30 feet per minute. The workers should be 8 inches from the nearest potatoes they are grading, should not reach more than 26 inches, and should have 3 feet of space at the table.[3] Fifty to sixty hundredweight of potatoes per hour can be inspected by each worker when proper conditions are provided, such as adjustable platform height, approximately 100 foot-candles of light at the table, and a comfortable working temperature.

Sizing

Potatoes not removed from the grading table (U.S. No. 1 grade) during the grading operation are moved on to a sizing operation. They are sized as they pass across a series of rotating rubber rollers (fig. 6, *A*). Tubers smaller than the openings provided by the roller spacing fall through to the belts below. A distribution of size is provided by having a range of roller spacings across the sizer. Division of this distribution into size categories is accomplished with dividers and take-away belts beneath the rollers.

Many plants do no further sizing, but others pass some of these sized potatoes to another more accurate machine for further classifying by shape or weight. A shape sizer classifies the tubers by their profile (shape) as they pass singly before light beams (fig. 6, *B*). More commonly used weight sizers classify the tubers according to their weight as they pass singly in cups across weighing mechanisms (fig. 6, *C*). All three of these sizers can divide the bulk potatoes into uniform-appearing classes of potatoes.

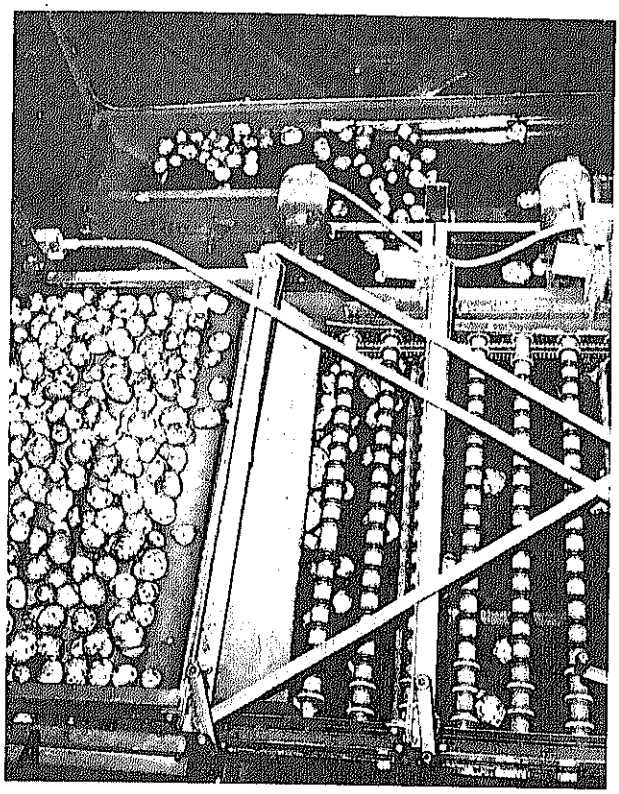
Filling and Closing the Containers

Filling 100-Pound Burlap Bags

Potatoes to be packed in 100-pound burlap bags are moved from beneath the sizing rollers to a distribution table. The table consists of a wide, flat belt for transporting the tubers, dividers for keeping the sized categories separated, and bagging

[2] See footnote 1.

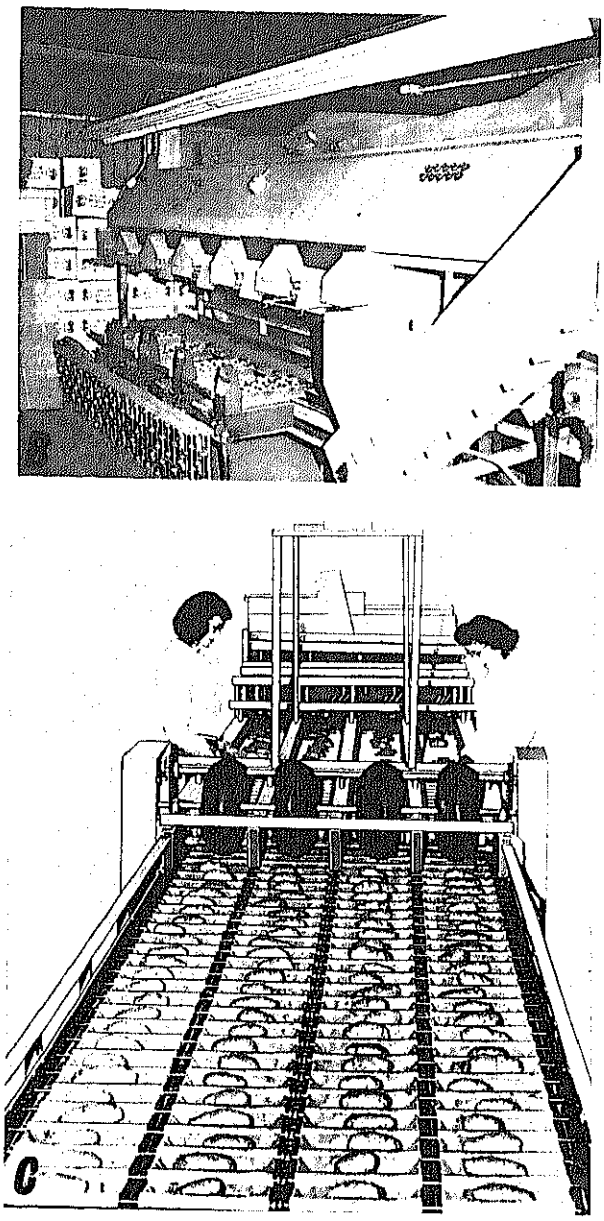
[3] See footnote 1.



PN–3106, PN–3107, PN–3108
FIGURE 6.—Expanding pitch roller (*A*), profile (*B*), and weight (*C*) sizers.

heads for filling the bags (fig. 7). Two bag holders per station are generally used. A hand-operated diverter directs the flow to the desired bag at each station. During the filling operation, a worker at each station obtains an empty bag, attaches it to the holder, and adjusts the diverter to direct the flow of potatoes into the bag. While one bag is being filled, he checkweighs and detaches the filled bag from the second bag holder at his station. He then passes the filled bag to another worker for closing. This cycle is repeated by a worker at each station. When the filling is done directly, an over-under reading scale is used for checkweighing. A worker can fill and checkweigh about 100 hundredweight per hour.

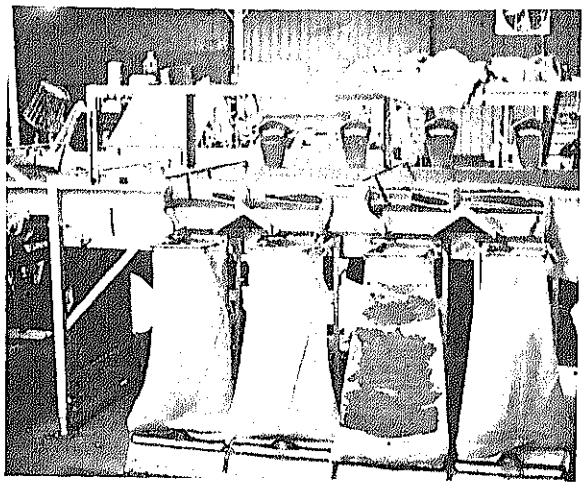
Semiautomatic bagging machines are also available to mechanize the filling of 100-pound burlap bags. Several ideas are being tried with these units, but basically all require (1) a hopper for maintaining a supply of potatoes at the bagger, (2) a feed conveyor for regulating the flow of potatoes to the bags during filling, (3) a bag-holding and



transferring mechanism for moving the bags through the unit during the filling cycle, and (4) a weighing mechanism to determine the correct fill for each bag.

Closing 100-Pound Burlap Bags

Often 100-pound burlap bags are closed by handstitching. After the bag is filled and checkweighed at the bagging head, it is passed to the worker whose task is to sew it shut. This worker grasps the filled bag by the open end and bounces it slightly to settle the contents and expose more



PN-3109
FIGURE 7.—Bagging stations for filling 100-pound burlap bags at a distribution table.

flap. He then handstitches the flap in a manner that leaves two "ears" with which to grasp the filled bag.

Machine sewing of 100-pound burlap bags is generally used with the semiautomatic bagging machine. A standard industrial sewing machine stitches the bag closed as it passes through the unit on a moving conveyor belt. A larger bag is used for machine-sewn closures in order to obtain extra material for the seam.

Filling Small Bags

Potatoes to be packed in small bags move from the sizer to a special grouping of machines in the plant. The main unit of equipment in the group is the semiautomatic bagging machine.

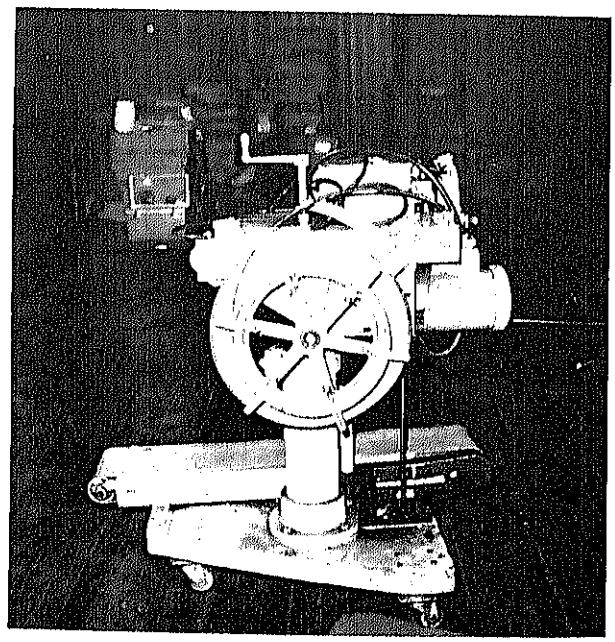
As with the 100-pound bagger, this unit utilizes a hopper, a feed conveyor, a bag transfer mechanism, and a weighing device. Paper, mesh, and polyethylene bags are commonly filled by these machines in 5-, 8-, 10-, and 20-pound sizes. A worker generally attaches the empty bags to the filler, but attaching devices are becoming available. Checkweighing is done by a worker who adds or removes tubers to obtain the desired weight as indicated by the scale on the machine. Output in hundredweight from small-pack baggers will vary widely depending on the type and size of bag being packed.

Closing Small Bags

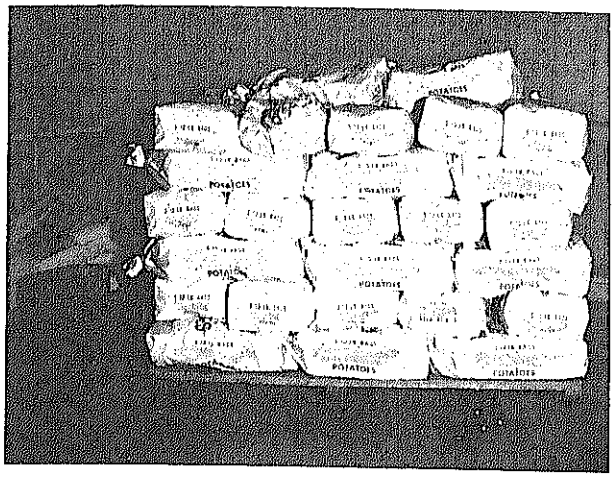
After the bags are filled at the bagger, they pass directly to a bag-closing machine. The method of closure and the machine used depend somewhat on the bag material. Some bags utilize an integral drawstring, which is pulled tight and clipped to form the closure. Paper bags may be machine sewn or tied with a metal ring by machine (fig. 8). Some polyethylene bags may be passed through a heat device to form the closure. Each method requires different equipment.

Baling Small Bags

To obtain some of the advantages of unitization, 5- and 10-pound bags of potatoes are assembled into 50-pound units by baling. Five 10-pound or ten 5-pound bags are placed in paper or polyethylene master containers (fig. 9). The operation includes accumulating the small bags, filling the master container, and closing it. Hand placing of the bags is generally practiced. Accumulating tables and baling frames are used for this operation. The master container is closed by methods and



PN-3200
FIGURE 8.—Ring-tying machine used to close bags in potato packinghouses.



PN-3201
FIGURE 9.—Master containers each enclosing five 10-pound bags of potatoes.

equipment similar to those used to close the small bags.

Filling Corrugated Boxes

Because potatoes shipped in 50-pound boxes generally must meet both a count and weight specification, the box filling is done in conjunction with a weight or shape sizer. Each outlet belt from the sizer has its own box-filling station to maintain separation of the size categories (fig. 10). Here a worker fills each box directly from the conveyor and then passes it to a worker who checks the weight at a scale. One-piece boxes or lower sections of telescoping two-piece boxes are formed as they are needed from flat stock that is precut and preformed. At each box-filling station, equipment consists of a box-holding device and a conveyor to deliver the filled box to the checkweighing closing section. Six or eight boxing stations may be in operation at a large weight sizer.

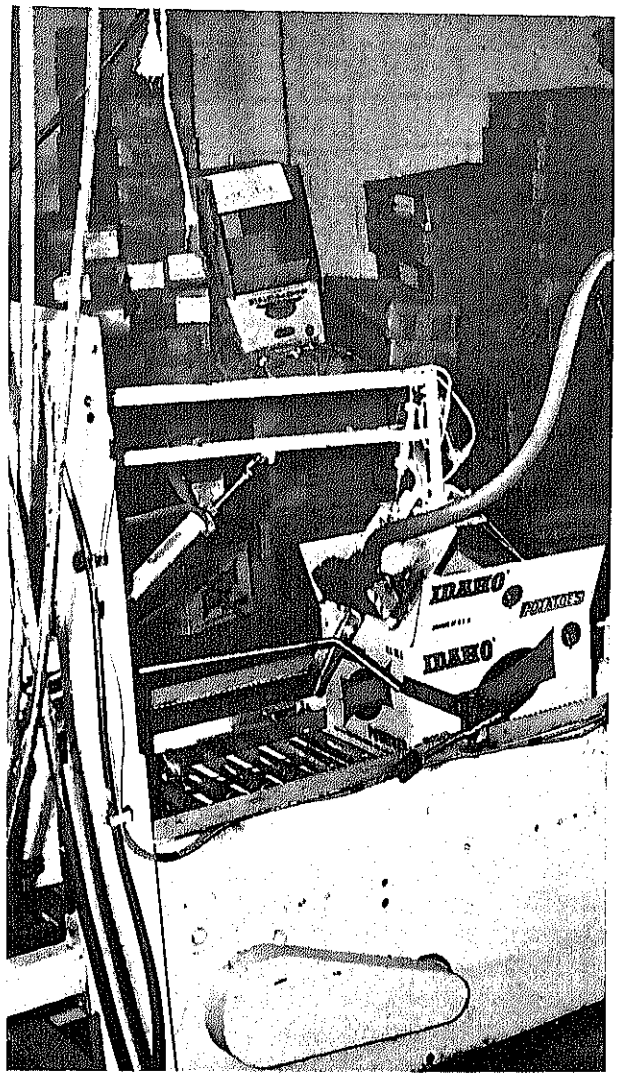
Closing Corrugated Boxes

The 50-pound boxes are closed either by folding and sealing the flaps on the one-piece box or by adding the top half of the telescoping two-piece box. Gluing and stapling devices are available to mechanize these operations (fig. 11). Belt and roller conveyors also can be utilized to transfer the boxes.

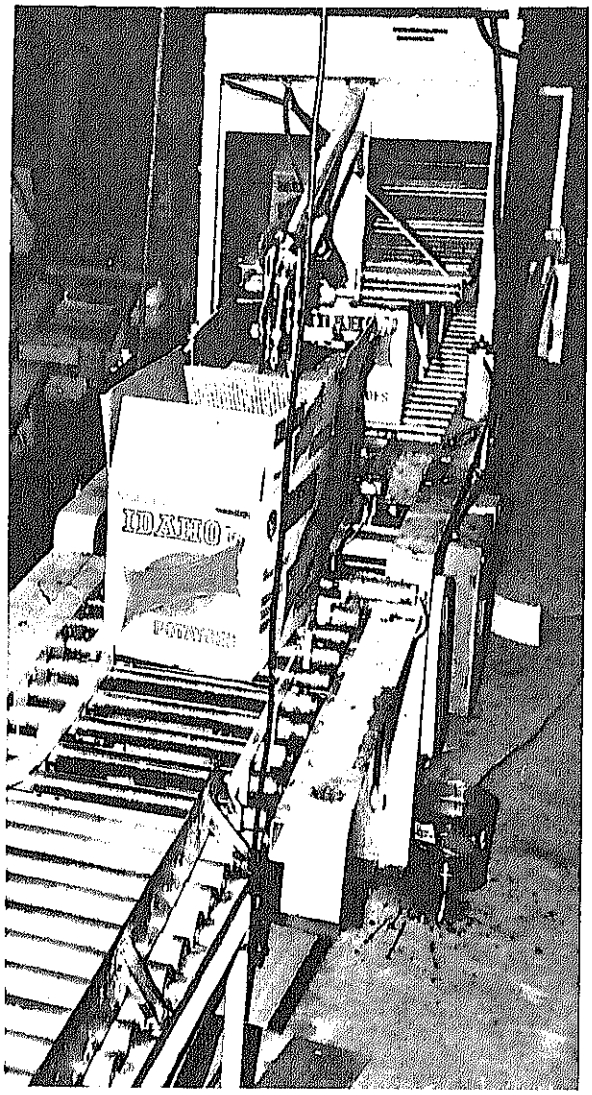
Handling Filled Containers

Handling 100-Pound Burlap Bags

After the 100-pound burlap bags are filled and stitched, they are tipped onto a nearby floor-level bag conveyor (fig. 12) to be transferred to either a railroad car or a highway truck for loading. In small plants this operation may involve a worker using a handtruck to move four bags per trip from the bagging stations to the transporting vehicle, where a worker stacks them in a predetermined arrangement for shipment.



PN-3202
FIGURE 10.—A box-filling station at a weight sizer.



PN-3203

FIGURE 11.—Equipment used to close boxes of potatoes after filling.

Handling Small Bags

Small bags in bales are moved directly to the railroad car or truck on conveyors. The bales are stacked in the carrier by hand in a predetermined pattern. Twenty-pound bags may pass directly from the packing line to the carrier on conveyors or may be accumulated on large pallets to be moved to the carrier later.

Handling Corrugated Boxes

Because several categories of potatoes are boxed simultaneously when the plant is operating, some of the categories must be held temporarily, although others may go directly to a carrier for shipment. Conveyors generally are used to move filled boxes directly to the carrier, where workers stack them by hand. The boxes being held are stacked by hand on pallets to be moved to a storage area. A forklift truck is generally used to move the pallets (fig. 13). Later, when loading space and equipment become available, the pallet load will be transferred to the carrier for shipment.

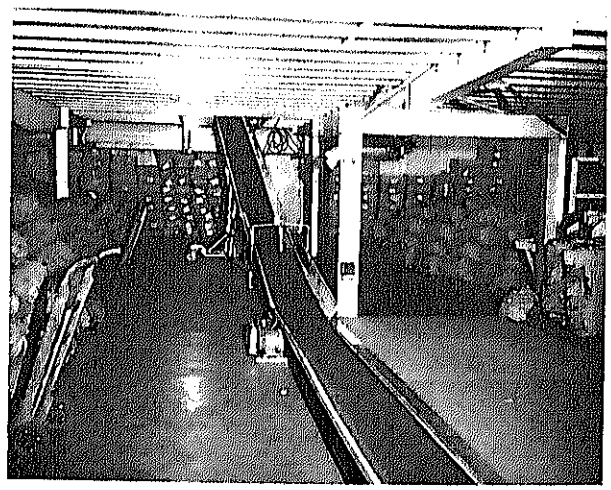
Handling Undergrade Potatoes

Handling No. 2 Potatoes

Potatoes considered to be of U.S. No. 2 grade are separated from the main flow of product (No. 1 grade) at the grading table. These potatoes are collected by a flat belt, usually beneath the grading rollers, and either transferred to an accumulating bin to be packed later or transferred to equipment to be packed immediately. If transferred to an accumulating bin, the No. 2's will likely be re-run through the wash line and packed by means of the equipment. If packed immediately, separate equipment may be required.

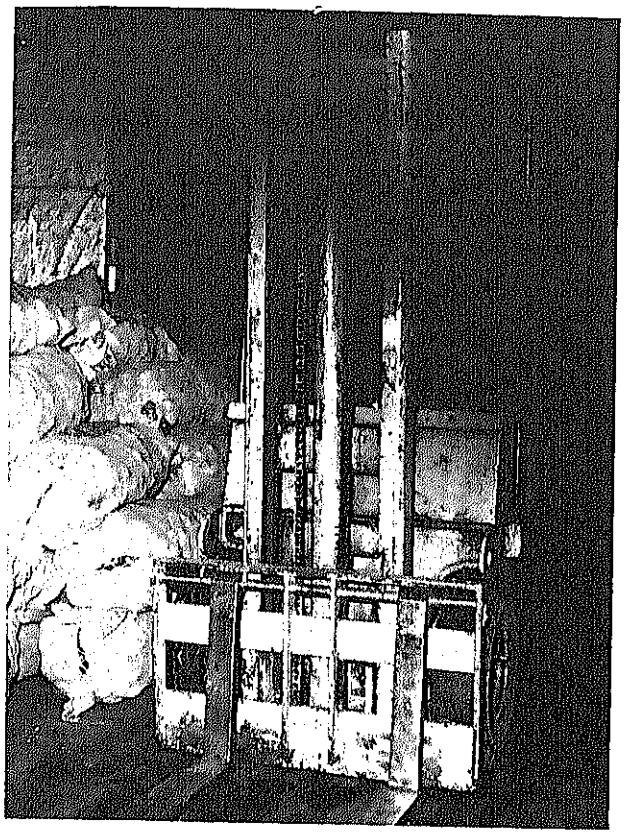
Handling Cull Potatoes

Cull potatoes may originate at the presizer, the pregrading table, or the main grading table. An



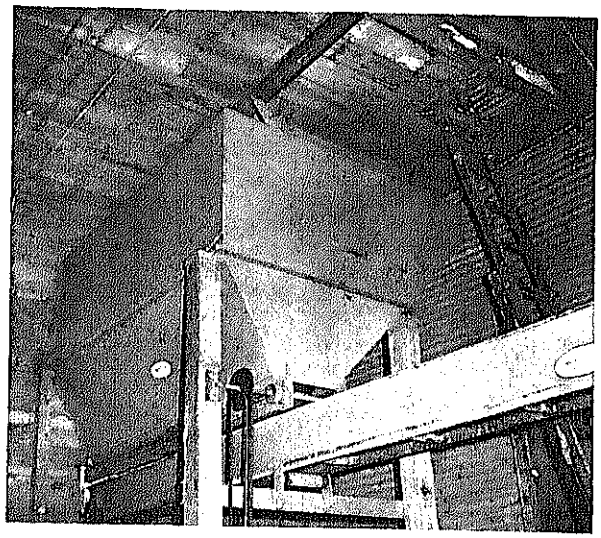
PN-3204

FIGURE 12.—Conveyor for transferring bagged potatoes from packing to shipping area.



PN-3205
FIGURE 13.—Forklift truck used to move pallet loads of packed potatoes.

arrangement of conveyors or a flume system may be used to gather the culls and transfer them to an accumulating bin (fig. 14). Here they are held until enough volume warrants removal from the plant by a farm truck. Moisture and odor problems may require a separate area in the plant for cull accumulation bins.



PN-3206
FIGURE 14.—A hopper-bottom bin for accumulating cull potatoes.

EXAMPLES OF PACKINGHOUSE LAYOUTS

Three example layouts were developed to illustrate the procedure used in arriving at a floor plan for a packinghouse.

The operator planning to build a potato packinghouse should retain the services of a professional engineer:

- To design the packinghouse to meet the operator's particular needs;
- To meet local regulations; and
- To supervise construction.

The equipment, operations, work methods, and procedures referred to in the examples typify those found in the industry. The choice of a certain type of equipment in these examples is for illustration purposes as much as for production characteristics, since several types can perform the required function well. For example, three types of receiving equipment are shown in the three layouts to illustrate the range of possible selections. The layouts are described in terms of equipment requirements and packing operations in a general way.

The structure housing the packing line is illustrated in the floor plan only. Several types of structure are feasible for each plant. Space is allocated for office and personnel requirements to emphasize proper provision for and arrangement of these facilities.

A mezzanine is used to provide a more effective layout. The height of such structures and of the plant itself should be suitable for the application involved. Elevations of conveyors, docks, and access doors should coincide with the requirements of the most frequently used carriers.

In all three layouts, mechanization of the operations is emphasized. However, flexibility of handling is maintained so that no choice of container or method of handling is eliminated unnecessarily

by the mechanized facilities. For instance, the telescoping loader used in layout A was selected because it allows the loading of bulk potatoes or of 100-pound bags, 50-pound bales, or smaller containers into either trucks or railroad cars.

The equipment selection for capacity was done on the basis of maintaining a specific rate of hourly input to the line—75 percent of which was U.S. No. 1 grade potatoes. The other categories, such as culls, undersize, and U.S. No. 2 grade, were considered as varying over a range. The equipment was selected to handle the potatoes resulting when the quality range of individual categories caused the greatest flow of potatoes through a particular item of equipment.

The following composition of line input was used as a guideline in determining equipment capacities for the example layouts:

Category	*Range (percent)*	*Average (percent)*
Culls	5–20	9
Undersize	1–10	4
U.S. No. 2	5–25	12
U.S. No. 1		75

Layout A

Operating Procedures and Facilities

Layout A (fig. 15) is designed for a rated input capacity of 200 hundredweight per hour. Expansion of the capacity of this line to handle an input of up to 250 hundredweight per hour is possible by altering equipment operating speeds and providing additional workers to smooth out operations as crop quality or size distribution may require. The potatoes are received in bulk from an onsite storage by way of a flume into the sump area beneath the floor. After they are washed and graded, they may be shipped in bulk, in 100-pound burlap bags, or in smaller bags. Limited prepackaging may be accomplished with the small two-head bagger.

Generally, the bulk or bagged U.S. No. 1 grade potatoes will pass directly to the transporting vehicle, and the U.S. No. 2 grade and the oversize potatoes will be bagged and placed in temporary storage to accumulate until the volume necessary for shipment is obtained. The layout facilitates this general product flow without unnecessary crossovers. The fully movable telescoping loader provides for the handling of potatoes in bulk or in various sizes and types of containers to either railroad cars or highway trucks with the same single unit of equipment. The side-by-side arrangement of the bagging heads for the No. 2 grade and the oversize potatoes allows one worker to attend to bagging both categories of potatoes.

The building is 68 feet long and 40 feet wide. If rail loadout is used, a rail spur should pass along the building at the loadout end. Truck and rail loadout may be accomplished through the same access port, but a second truck loadout is also provided.

Cull potato-handling facilities include a temporary overhead holding bin at the sump area for accumulating cull material for removal by farm truck.

The required packing materials are stored above the office and personnel facilities. Swing-up stairs provide a removable access to this area.

Office space is located so that activities within the plant can be readily observed. Restroom and other employee facilities are provided.

Equipment Requirements

The required items of equipment, as numbered in figure 15, are as follows: (1) A draper-chain elevator 24 inches wide and approximately 14 feet long to separate the tubers from the flume water and transfer them from the sump to the packing line; (2) a 24-inch-wide screen sizer to remove undersize tubers, small stones, and trash from the main flow of potatoes and provide for their disposal by way of a bagging head or cull conveyor; (3) a 36-inch-wide, transverse, brush-roller washer, sponge-dryer combination, with a minimum of 10 brush rollers available in the washer and eight absorber rollers in the dryer; (4) a 30-inch-wide grading table to rotate and convey the tubers for a distance of about 10 feet; (5) a 12-inch-wide, flat-belt conveyor to move cull potatoes from the grading table to the cull elevator; (6) a 12-foot-long elevator to lift the cull material to an overhead cull bin; (7) a hopper-bottom cull bin with a plow-off conveyor for filling and a telescoping conveyor for emptying; (8) an 18-inch-wide roller table or belt conveyor to transfer the No. 2 grade potatoes from the main grading table and to provide 100-pound bagging facilities for

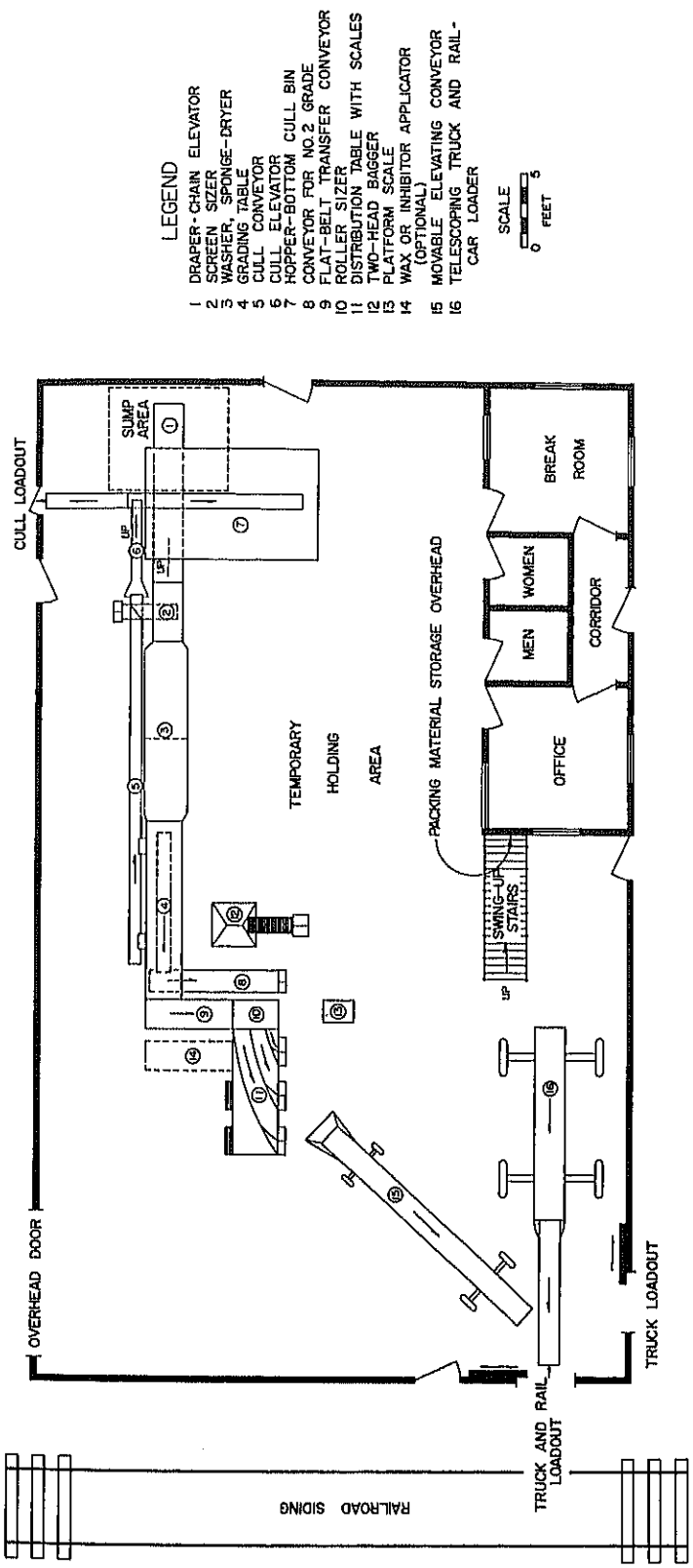


FIGURE 15.—Layout A; designed for a potato packinghouse with a rated input capacity of 200 hundredweight per hour.

that grade; (9) a 24-inch-wide by 6-foot-long, flat-belt transfer conveyor; (10) a 24-inch-wide roller sizer to size the No. 1 grade; (11) a 42-inch-wide by 13-foot-long, flat-belt distribution table to maintain the divisions of the sized product and to transfer the potatoes to bagging stations (the oversize station need not have semiautomatic scales, but the other two should have); (12) a two-head bagger for limited small packaging; (13) a platform scale for checkweighing 100-pound burlap bags filled at the oversize and No. 2 bagging heads; (14) a wax or sprout-inhibitor applicator (optional) to replace item 9 when such application is desired; (15) a 25-foot-long elevating conveyor on wheels to handle potatoes from the distribution table to the loader in bulk or bag; and (16) a telescoping, 180° rotation loader (fig. 16) for loading either bulk or bagged potatoes into a railcar or highway truck. (The unit should be mounted on wheels if a second truck loadout is desired.)

Layout B

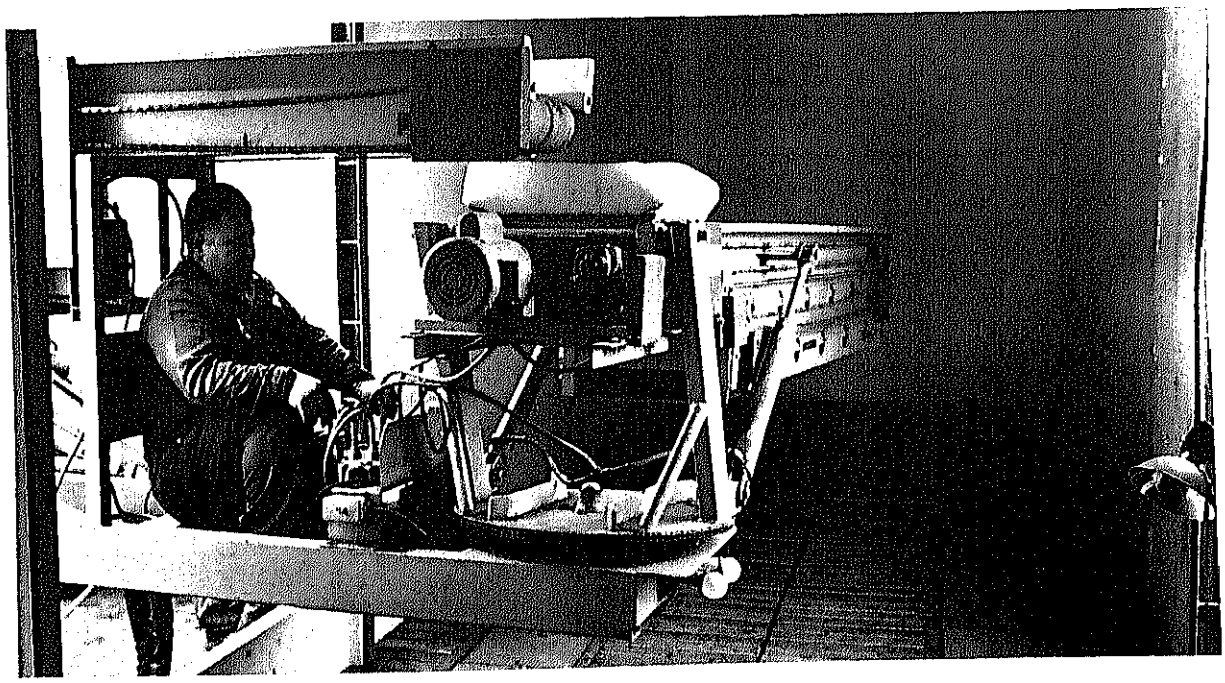
Operating Procedures and Facilities

Layout B (fig. 17) is designed for an input rate of 400 hundredweight per hour. Potatoes are received in bulk via a flume system from onsite storage bins. However, additional truck or rail deliveries may be received at the plant. Trucks may be unloaded into one of the empty onsite storage bins, and railroad cars are unloaded into a flume at the sump end of the enclosed railroad siding. Output consists of packed 100-pound burlap bags and all common types and sizes of consumer packages except boxes.

The layout offers some choice of product division and utilization to obtain better market value from the potatoes being packed. Reversible belt conveyors, diverters, and multiple bagging stations are used so that each size and grade of potato may be packed on the main floor at the 100-pound bagging stations or diverted to the mezzanine to be packed in small bags.

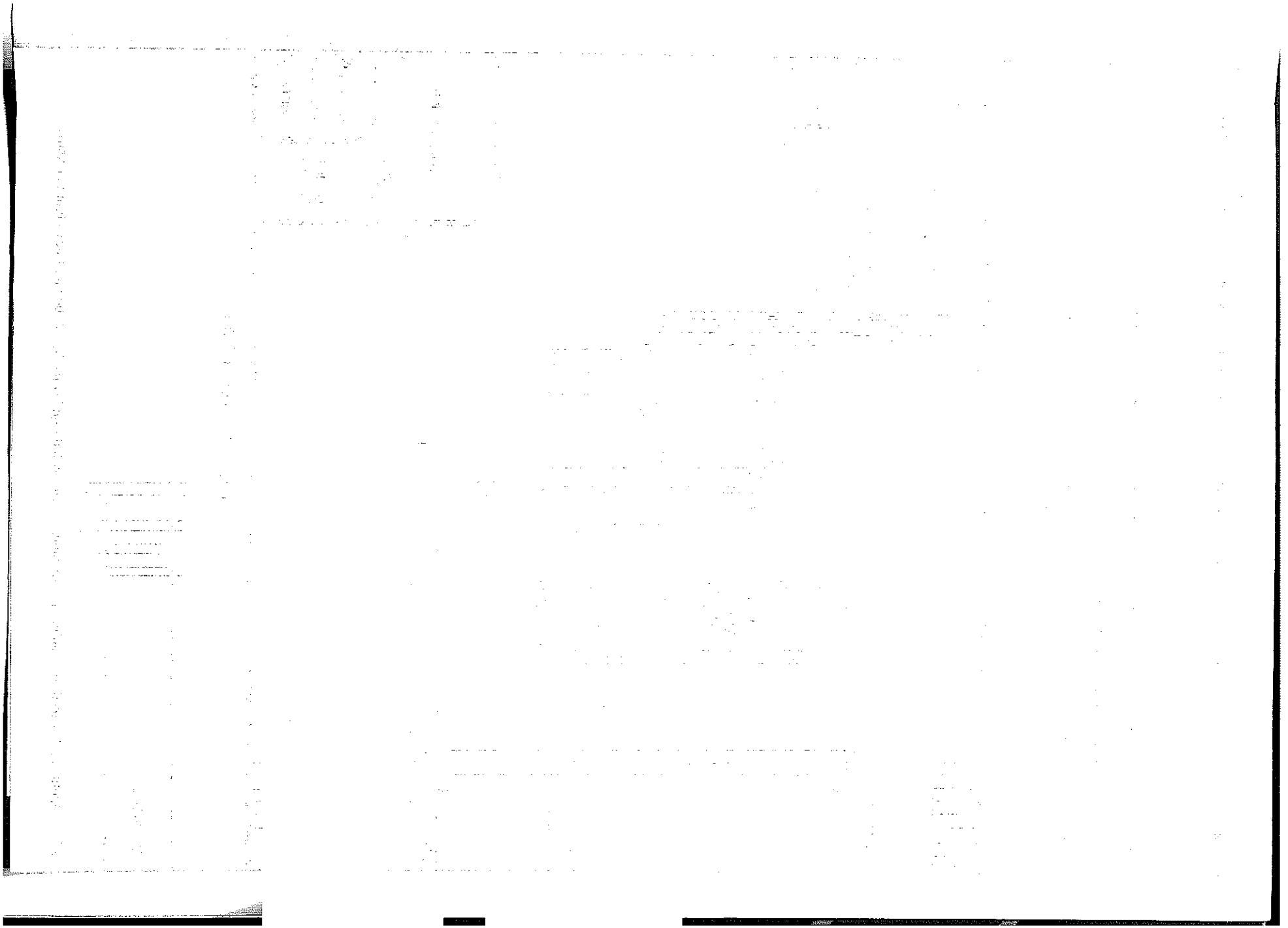
This layout emphasizes fully mechanized handling of the packed product. Handling and flow options are provided by reversible bag conveyors, diverters, and several loadout ports. The small-bag closing and baling equipment is fully movable and may be arranged to reach any one of the loadout conveyors.

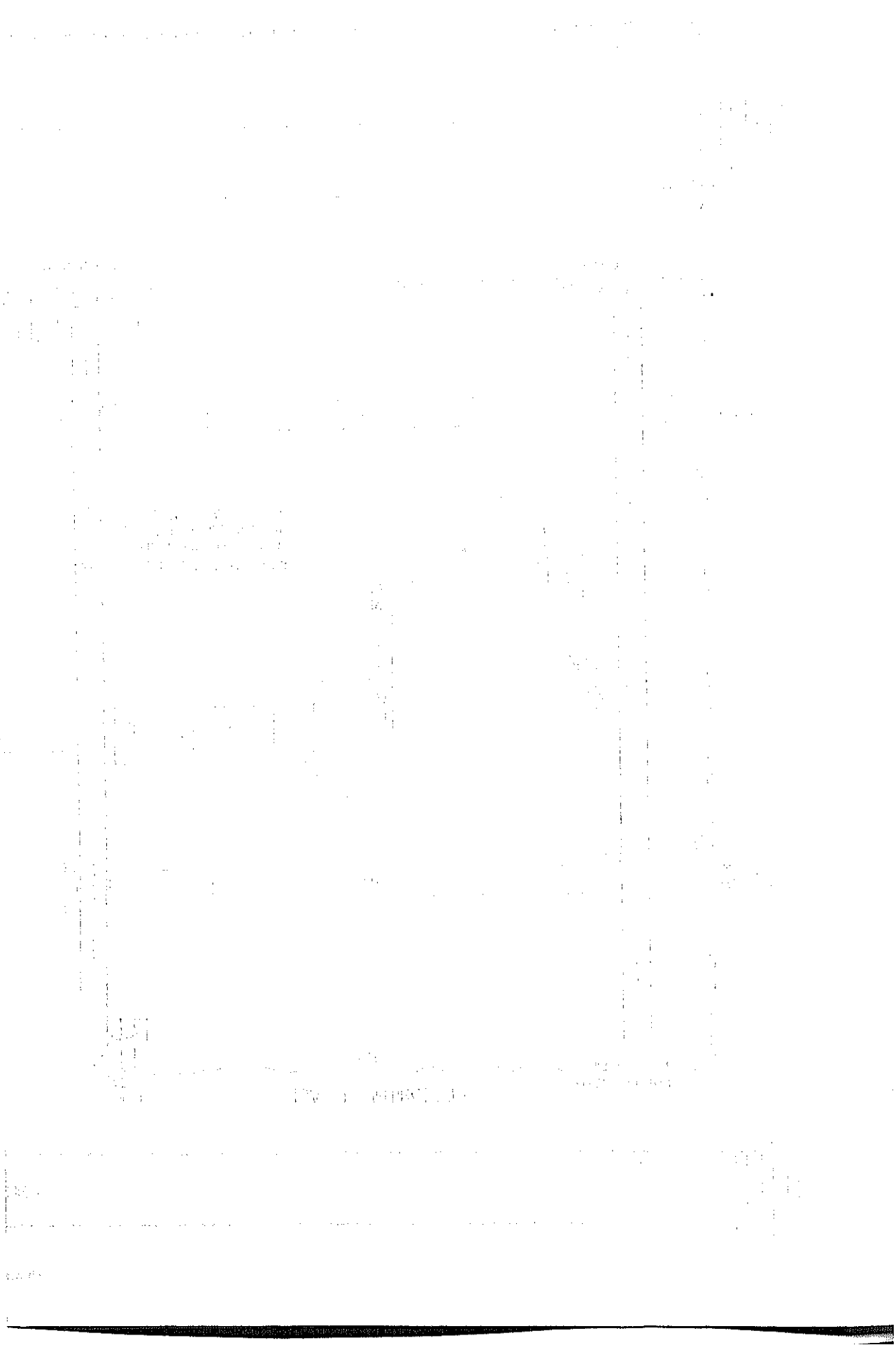
Shipping accommodations include both open and enclosed railroad sidings. Four loadout ports



PN-3207

FIGURE 16.—A telescoping, 180° rotation loader for placing bulk or bagged potatoes into railroad cars or trucks.





are provided for railroad car loading. Trucks are accommodated at two loadout ports at the end of the building. Temporary storage for the packed product and for packing materials is available on the main floor beneath the mezzanine. The packed product also may be stored temporarily at the walls of the mezzanine.

Cull potato-handling equipment is designed to gather the material from the packing line on belt conveyors and elevate it to an overhead bin. There it is accumulated until transferred to a farm truck by way of a telescoping conveyor in the bottom of the bin.

The location and arrangement of the office and employee facilities provide for isolation from plant activities and for observation of the packing line from the plant office. Further separation of types of activities at the office and employee facilities from those of the packing area is provided by the two-level arrangement of the facilities.

The section of the building that houses the packing area is 126 feet long and 55 feet wide. The enclosed railroad siding adds another 18 feet to the width of the building. The mezzanine abuts three walls of the packing room and extends over the main floor for 44 feet.

Although 400 hundredweight per hour is the design input, the washing and preparation section of the plant has built-in capabilities of up to 500-hundredweight-per-hour input without changing equipment size or location. Further expansion of a packing line such as this one would likely involve the addition of sizing and boxing capabilities. A simple expansion for this purpose may be accomplished by extending the mezzanine out over the main floor area for an additional 30 to 35 feet. A sizing and boxing operation on the mezzanine may be blended easily into the existing handling equipment. A more elaborate approach to providing additional packing capability would include locating the sizing and boxing equipment beneath the mezzanine on the main floor and adding a storage facility for packed products at the end of the existing structure. This arrangement would provide both the temporary storage and additional trackside loading capabilities needed when several size categories are packed. Truck loading from the packing area then would be by way of the rail loadout ports at the open railroad siding. Any such expansion of the building should be anticipated when planning the original site.

Equipment Requirements

The required items of equipment, as numbered in figure 17, are as follows: (1) A vertical elevator 60 inches wide to transfer the potatoes from the sump to the packing line; (2) a 48-inch screen presizer to remove undersize tubers, small stones, and trash; (3) a 48-inch-wide by 6-foot-long grading table for the pregrading operation; (4) a 60-inch-wide, transverse, brush-roller washer, sponge-dryer with a combined length of 14 feet; (5) a 30-inch-wide, flat-belt distribution conveyor to divide the potato flow between the two grading tables; (6) a 12-inch-wide, flat-belt cull conveyor to collect and transfer culls (12-inch-wide, cull-collection conveyors also pass beneath items 5 and 9); (7) a 12-inch-wide elevator for transferring culls to the overhead cull bin; (8) an overhead hopper-bottom cull bin with distribution and unloading conveyors; (9) two 30-inch-wide by 13-foot-long grading tables to rotate and convey the potatoes for grading; (10) an 18-inch-wide roller conveyor with a bagging head and flow diverter to provide for packing the No. 2 grade potatoes removed at the grading table; (11) a collection conveyor 30 inches wide by 15 feet long to combine the potatoes received from the grading tables; (12) a 48-inch-wide applicator for wax or for sprout inhibitor, with a built-in, flat-belt conveyor that allows potatoes to bypass the applicator; (13) a 48-inch-wide roller sizer providing four size categories to be removed by three reversible belts and one single-direction belt; (14) a 60-inch-wide by 16-foot-long distribution table providing five bagging stations, with semiautomatic scales, for packing potatoes into 100-pound burlap bags; (15) a 24-inch-wide, flat-belt conveyor to receive potatoes from any of the four size categories or the No. 2 grade and transfer them to the elevator; (16) a 24-inch-wide, bulk-potato elevator to transfer potatoes from the main floor to the bagging machine on the mezzanine; (17) two platform scales for checkweighing 100-pound burlap bags filled at the secondary bagging stations provided in this area of the layout; (18) a two-head bagging machine for any minor packaging from these stations; (19) a 24-inch-wide, movable, floor-level bag conveyor to transfer

filled bags from the secondary bagging stations to the conveyor (item 20) or to the elevator (item 21) for transfer to the mezzanine (this movable conveyor also may be used to transfer filled bags to and from the storage area beneath the mezzanine); (20) a 24-inch-wide, recessed, reversible bag conveyor to transfer 100-pound bags to either of the bag elevators (filled bags may be received from the bagging stations at item 14, from the secondary bagging stations by way of item 19, or from temporary storage beneath the mezzanine); (21) two 24-inch-wide bag elevators to transfer filled 100-pound burlap bags to the handling equipment on the mezzanine; (22) two 24-inch-wide, reversible bag conveyors, each with telescoping extensions at each end to transfer the packed products into railroad cars for loading; (23) two 24-inch-wide bag conveyors, each with a telescoping extension to enter the trucks for loading the packed products; (24) a semiautomatic bagger for filling small bags of various types and sizes; (25) two 12-inch-wide, small-bag conveyors, each with a powered back-rail belt to transfer the filled bags between other items of equipment; (26) a small-bag sewing, sealing, or clipping machine to close the filled containers; (27) an accumulator to smooth out the irregular flow of filled bags by regulating or holding them at the baling station; (28) a baling stand to serve as a work station and master container holder for the baling operation; and (29) a machine to close the master container or bale before it is placed on a nearby conveyor for transfer to the railroad car or truck.

Layout C

Operating Procedures and Facilities

Layout C (fig. 18) is designed for an input of 800 hundredweight per hour. As in layout B, potatoes are received at the packing line in bulk by way of a flume system from either onsite storage bins or from truck or rail deliveries to the plant. The packing facilities provide for an output in 100-pound burlap bags, in all common sizes and types of small bags, and in boxes.

This layout facilitates product division and provides the option of product recombination to obtain maximum market value from the potatoes being packed. Product division is accomplished through an arrangement of reversible, movable-belt conveyors at the initial sizer, which provides for the transfer of each of four size categories and the No. 2 grade to either the 100-pound bagging station, the small-bag bagging station, or any one of six holding bins. Recombination is accomplished by providing the holding bins with a set of outlet conveyors, which allows transfer of potatoes from each bin individually or from any combination of bins to either the 100-pound bagging station, the small-bag bagging station, or the secondary sizing and boxing station.

All operations involved in washing, storing, and packing may occur simultaneously with proper selection of flow paths for the various categories being washed and packed.

In general, the washing and cull-handling operations and the secondary sizing and boxing operations are located on the main floor; the grading and initial sizing and the 100-pound and small-bag bagging operations are located on the mezzanine. The holding bins rest on the main floor but extend up through the mezzanine level.

As in layout B, fully mechanized handling of the packed product is emphasized. Handling options for the bagged potatoes are provided by reversible conveyors, diverters, and the several loadout ports at the mezzanine level. Boxed potatoes are handled on pallets with a forklift truck.

Shipping accommodations at this plant include two enclosed railroad sidings, which are accessible through five loadout ports at the mezzanine level, three access doors from the main floor level, and an additional access door from the temporary storage facility. Trucks are accommodated at two mezzanine-level ports, two main-floor-level doors, and three doors in the temporary storage facility. Temporary storage is provided for the bagged products in the unused section of the mezzanine. However, some of the several categories of potatoes that come from the secondary sizing and related boxing operations must be held for some time after packing to accumulate required volumes, obtain markets, and await transportation. The storage facility shown on the layout can provide space for this temporary holding, with the required temperature and humidity control to maintain quality.

Cull potatoes from the washing and grading

erations pass through chutes to flumes beneath ch wash line. Water in the flumes carries the terial to the sump area, where it is elevated to a ll bin or removed directly to a farm truck.

Packing materials may be stored in volume on e mezzanine and on the main floor beneath the ezzanine.

As in layout B, the office and employee facili- s are located where they will provide isolation om plant activities but allow observation of the cking line from the plant office. The facilities ve two levels to provide for the most efficient lization of space and to separate the types of ivity at the office and employee facilities from ose of the packing line.

Because of the holding capabilities in the stor- e bins, equipment may be operated at full pacity continuously. Such operation will reduce ctuations in crew size requirements in the plant. ie quality of crop and the types of containers ng packed will still affect crew requirements newhat at particular machines, but most op- tions will be stabilized.

The main packing area in this building is 88 t wide and 200 feet long. The additional width enclosed railroad sidings is 36 feet, making the erall building 200 feet long by 124 feet wide. e temporary storage area is 70 by 50 feet, plus additional 18 feet of enclosed railroad siding. e mezzanine spans the width of the building at end and extends around the holding bin sec- n on three sides. Its length along the sidewalls 135 feet.

The washing and preparation section of the nt has built-in capabilities to expand the input e above the 800-hundredweight-per-hour de- n figure to 1,000 hundredweight per hour. This kinghouse is essentially complete in that it ers the three common types of containers—100- nd burlap bags, small bags, and boxes. How- r, some change of emphasis may be accommo- ed within the facility. For instance, an addi- nal small-bag bagging operation could be ac- mmodated on the mezzanine. Mechanization and ibility would be maintained by moving the sent bagging setup and supplying it and the litional unit via conveyors. Semiautomatic bag- g of 100-pound burlap bags could be installed the mezzanine, either to replace or to supple- nt the present bagging setup. Shipping in bulk could be easily accommodated by adding a bulk car-loading setup at the end of the mezzanine so as to receive potatoes from the present system by way of conveyor (No. 27 on the layout).

Equipment Requirements

Since many of the items of equipment in this packing line have been described in layouts A or B, only their number and size will be noted here. Those not mentioned earlier will be described. The items of equipment, as numbered in figure 18, are as follows: (1) A potato pump to transfer the potatoes from the sump to the packing line; (2) two 48-inch screen presizers; (3) two 48-inch-wide by 6-foot-long grading tables for the pregrading operation; (4) two 60-inch-wide by 14-foot-long washer, sponge-dryers; (5) two 36-inch-wide, draper-chain elevators to transfer the potatoes to the grading tables on the mezzanine; (6) a small flume system to collect cull potatoes from each half of the double wash line and transfer them to the sump area; (7) a 24-inch-wide vertical elevator to lift the cull potatoes to a reversible, movable, flat-belt conveyor, which will remove them from the building or place them in the cull hopper; (8) a hopper-bottom, cull-holding bin; (9) two 48-inch-wide by 14-foot-long grading tables; (10) two wax or sprout inhibitor applicators with bypass units; (11) two 48-inch-wide roller sizers; (12) a reversible, movable, flat-belt conveyor to transfer the No. 2 grade potatoes to any holding bin or to either bagging setup on the mezzanine; (13) four reversible, movable, flat-belt conveyors to transfer the four size categories of potatoes to any of th[illegible] and to the two bagging setups on the mez
(14) a return-flow distribution table wi bagging stations, all with semiautomati
(15) six 12-inch-wide, flat-belt convey plow-off diverters for filling the holdi
(16) six hopper-bottom holding bins wit end sloped and extended to provide a point for filling; (17) a semiautomatic ba small bags; (18) a small-bag closing (19) a small-bag transfer conveyor; (2(cumulator; (21) a baling stand; (22) closing machine; (23) two 24-inch-wide, r bag conveyors with telescoping extens truck loading; (24) five 24-inch-wide, conveyors recessed in the floor surface for car loading; (25) two 24-inch-wide, revers

belt conveyors to receive potatoes from the holding bins and transfer them to either of two receiving hoppers; (26) two 24-inch-wide, bulk potato elevators to transfer potatoes back to the baggers on the mezzanine; (27) two 24-inch-wide conveyors for transferring combinations of potatoes from several bins to a point where the pivoting conveyor of the secondary sizer may obtain them; (28) six 24-inch-wide, bin-unloading conveyors beneath the holding bins, each with a diverter for transferring flow to item 25 and each of a length that matches the path of the pivoting conveyor (item 29); (29) a 24-inch-wide, movable conveyor to pivot about the main hopper of the sizer and transfer potatoes to it from the eight locations at which they may be received; (30) a weight or shape sizer with at least six size categories available; (31) box-filler setups to allow filling boxes at the output of each station available on the sizer; (32) belt and gravity conveyors for transferring the filled boxes to the checkweighing and closing stations; (33) an on-line scale and work station for checkweighing the filled boxes; (34) a box-closing machine for either gluing or stapling the boxes shut for shipping; and (35) a forklift truck for transferring pallet loads of filled containers to carriers or temporary storage.

A box-makeup area (not shown in fig. 26) is required immediately above the sizer (item 30). This is a 20- by 30-foot islandlike mezzanine with protective railings, a personnel access, and the proper number of metal chutes connecting it with each box-filling station (item 31). Workers on this mezzanine prepare the empty boxes from flat stock stored on the mezzanine and place them in the chutes. This provides a continuous supply of the proper boxes prepared for filling to each filling station during operation.

In addition, pallets, handtrucks, and occasional belt or gravity conveyors will be required for the efficient handling of filled containers and packaging materials within the plant.

CREW REQUIREMENTS

Table 1 shows the estimated crew sizes required when operating the packing lines shown in the three example layouts. These crew requirements should be considered "typical" only, since changes in product quality, container, production rate, and handling operations can alter the numbers and types of workers needed at any one time. These estimates are based on input rates of 200, 400, and 800 hundredweight per hour for layouts A, B, and C, respectively.

Labor requirements are rather low and stable in the small packinghouse (layout A), since the pack used is primarily the 100-pound burlap bag. Crew requirements range from 7 to 12 workers in this plant, with the lowest number required when the product quality is good and shipment is in bulk.

Crew requirements for the plant in layout B would probably range from 24 to 35 workers depending on the type of order being packed and the quality of the crop. The estimate of 29 workers in table 1 is based on a division of the product flow between the 100-pound bagging stations and the small-bag filling stations. Crew requirements could be quite different if only one of these units is operated. However, most plants will attempt to have the workers available even if they are not fully utilized for a short time.

The packing line in layout C can divide and divert product flow to and from storage bins and packing stations. Labor and equipment utilization can be rather high for all operations and at

TABLE 1.—*Estimated number of workers required for 3 potato packinghouse layouts*

Operation	Layout A	Layout B	Layout C
Flume potatoes to line	1	1	1
Prograde	1	2	4
Grade	2	6	12
Pack undersize and handle culls	4	2	1
Pack and handle No. 2 grade			3
Pack and handle No. 1 grade		12	23
Loadout or transfer to storage	2	4	10
Supervise [1]	1	1	2
Maintenance		1	2
Total crew	11	20	58

[1] Supervisor assists as necessary at any operation except fluming.

the same time can offer more variety in size and pack. Crew requirements here are estimated to be from 50 to 65 workers, with 58 shown in table 1. This number assumes activity at all packing stations.

These estimates are presented as guidelines for layout planning and are not production standards. They are intended to aid in estimating labor requirements when similar potato packinghouse layouts are being developed.

EQUIPMENT COSTS

Table 2 lists estimated initial costs for the items of equipment shown in each of the example layouts. It is intended only as a general guide in estimating initial costs for the individual items or groups of equipment needed when a particular method of operation is planned for a plant. The costs reflect 1972 prices as estimated by the equipment suppliers. Installation charges are included but not shipping charges and utility service to the equipment.

TABLE 2.—*Estimated initial cost of major equipment for 3 potato packinghouse layouts*

Equipment	Layout A		Layout B		Layout C	
	Item No. on plan	Initial cost	Item No. on plan	Initial cost	Item No. on plan	Initial cost
Elevator	1	$1,000	1	$4,500	1	$15,000
Presizer	2	1,000	2	1,300	2	2,600
Prograder			3	975	3	1,950
Washer, sponge-dryer	3	3,100	4	4,200	4	8,400
Grading table	4	1,300	9	3,160	9	4,380
Wax applicator with bypass	9, 14	3,000	12	4,775	10	9,550
Roller sizer	10	2,575	13	6,550	11	12,100
Distribution table	11	4,000	14	5,700	14	8,500
No. 2 grade conveyors	8	800	10	970	12	1,270
Cull-handling conveyor	5, 6	2,150	6, 7	1,750	6, 7	1,850
Hopper-bottom cull bin	7	5,350	8	10,200	8	10,700
Two-head bagger and scales	12, 13	3,500	17, 18	4,000		
Semiautomatic bagger			24	15,000	17	15,000
Small-bag closer			25, 26, 27, 28, 29	8,500	18, 19, 20, 21, 22	8,500
Bulk-transfer conveyor			5, 11, 15, 16	6,600	5, 13, 15, 25, 26, 27, 28, 29	52,350
Loading conveyors	15, 16	8,800	19, 20, 21, 22, 23	35,400	23, 24	25,860
Bulk potato bins					16	21,000
Weight sizer					30	20,000
Box filler-closer					31, 32, 33, 34	18,000
Forklift truck					35	6,000
Total		37,475		113,580		243,010

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